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RESEARCH STUDIES IN COLLEGE SCIENCE FROM JULY 1963 TO JULY 1964.

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DESCRIPTORS- *COLLEGE SCIENCE, *TEACHER EDUCATION, *CURRICULUM, EVALUATION, EDUCATIONAL OBJECTIVES, EDUCATIONAL PHILOSOPHY, EDUCATIONAL RESEARCH DESIGN, LEARNING, LEARNING THEORIES, SCIENCE EQUIPMENT, SCIENCE FACILITIES, TEACHING METHODS, AUSTIN

THE FINDINGS AND CHARACTERISTICS OF RESEARCH IN COLLEGE SCIENCE TEACHING COMPLETED FROM JULY 1963 TO JULY 1964 ARE ANALYZED IN THIS PAPER. THE STUDIES ANALYZED ARE GROUPED INTO NINE CATEGORIES--(1) PHILOSOPHY AND OBJECTIVES, (2) PUBLIC POLICY, (3) CURRICULUM, (4) LEARNING, (5) TEACHING METHODS, (6) FACILITIES AND EQUIPMENT, (7) TEACHER EDUCATION, (8) EVALUATION AND RESEARCH DESIGN, AND (9) SUPERVISION. AN ANALYTICAL SUMMARY IS INCLUDED FOR EACH CATEGORY EXCEPT "SUPERVISION AND ADMINISTRATION" FOR WHICH NO COMPLETED RESEARCH WAS RECEIVED. A BIBLIOGRAPHY OF THE 59 RESEARCH REPORTS USED BY THE AUTHORS IS INCLUDED. THE AUTHORS OBSERVE THAT 38 OF 59 RESEARCH STUDIES WERE DOCTORAL THESES OR DISSERTATIONS. OVER ONE-HALF DEALT WITH TEACHING METHODS AND ALMOST EXCLUSIVELY IN FRESHMAN COURSES. MUCH STUDY OF "NEW" AND "TRADITIONAL" COURSES IS CITED. LEARNING, FACILITIES, AND EQUIPMENT ARE NOTED AS RECEIVING MORE RESEARCH SCRUTINY THAN IN THE PAST. MANY STUDIES, THE AUTHORS STATE, SUFFERED FROM FAULTY DESIGN. (RS)

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In the period from July 1963 to July 1964, 59 studies were reported dealing with some facet of science education at the college and university level although several were not published until 1965. From this group, 24 studies have been selected for abstracting. Some papers have been included in this section not so much for the high quality of the research, but because they represented first attempts in areas previously unexplored to any great extent. All 59 reports are categorized into the nine "fields for investigation" suggested by the National Association for Research in Science Teaching. It should be noted that the section on administration and supervision is omitted due to the lack of studies seeming to fit clearly into this division. Several of the reports, particularly those in teacher education, might well have been included in either the secondary or elementary sections of this book, but have been included here, for, although they have implications for the teaching of elementary and secondary school science, they directly involved college and university courses for teachers. Other studies involved both advanced high school and college students, but have also been included in this section.

ANALYSIS

Studies Related to Philosophy and Objectives.--Only one study was completed which seemed to belong to this field of investigation, that done by Lerman. His survey of the changes in the teaching of college physics in the United States during the twentieth century showed little apparent change in the methods of teaching physics as revealed by comparing textbooks of physics, the periodical literature of college physics teaching, and other pertinent publications, from 1900 to the present.

Studies Related to Public Policy.--Nichols and Strauss both made significant studies related to selection of scientific careers. The former involved nearly 68,000 semi-finalists in the National Merit Scholarship Program from 1957-63 and found that scientific research, engineering, teaching, and medicine were the most popular fields. Although science and engineering continued to attract a large number of students, this trend was decidedly downward and the popularity of the humanities and social sciences was increasing. The popularity of physics as a major field of college study showed the greatest decline among the sciences. One encouraging sign is that among this group of highly able students, teaching as a career was rising in popularity, especially among males. The Strauss study was made of 162 professors from the University of Wisconsin and nine European universities in biological science, physical science, social science, and the humanities. All were established researchers and were interviewed in person to determine what influenced selections of their general and specialized career fields. It was concluded that in making career choices the most important time is the undergraduate period, and the most important influence is self-generated interest in the subject matter, with teachers playing a decidedly secondary influential role.

Two studies involved advanced degrees, one dealing with doctorates in education (Strauss), the other with potential doctorates in geology, geophysics, and oceanography (Henderson). Henderson found in an AGI survey of 171 schools that the supply of undergraduate majors in geoscience is too small to furnish continued growth at the graduate level in this field. Strauss surveyed 6,968 doctorates conferred by United States universities in 1957 of which 1,078 were in education. Upon analysing their high

school backgrounds he found that when compared with doctors in other major fields, those in education had been lowest in high school graduating class rank, had come in disproportionate numbers from small high schools, had attained their doctorates at a decidedly older age, had lower average IQ's when converted to the Army General Classification Test scale, and had fewer doctorates per thousand high school graduates in each of the nine geographic regions of the United States as defined in the study. The evidence also indicated that those who earned the Ed.D. (803) and those who had taken the Ph.D. in education (275) were very similar in their backgrounds.

Winslow's study of the services of American science educators in underdeveloped nations found that a total of 284 had served on over 350 separate missions in underdeveloped countries, 75% since 1960. These services involved writing textbooks and handbooks, teaching, directing teacher training, and speaking in numerous workshops and institutes. Seventy-five percent of the work was done in East Asia and definite trends were noted in the direction of an increased quantity of science education and elevation of standards in teacher training.

A study with interesting implications for science curriculum designers was completed by Richman and involved 171 experienced physical science teachers. Each teacher was sent an identical set of communications about a hypothetical new science curriculum, which varied only in the reported social status of its authors or the time spent in preparing the program, and the teachers were asked to react to it. The data collected showed that those science teachers, given a physical science course outline

allegedly written over a period of three years, accepted the outline at a significantly higher level than did science teachers who had received the identical communication presumably written over a period of only five days. A significantly higher acceptance was also reported for those science teachers who had received a course outline from a group of research scientists as compared with those who received the same outline from a group of laboratory technicians.

Studies Related to Curriculum.--Two studies were made of introductory college science courses, one in general biology and one in physics. Kochersberger in comparing the achievement of students in a community college with those in a university found that the community college provided satisfactory instruction in general biology with a better chance for academic survival among the less well prepared students. Using the PSSC physics curriculum with undergraduate non-physics majors, Henkel found certain general critical thinking abilities were more thoroughly developed than in a more traditional physics course.

Introductory college chemistry textbooks from 1930-60 were surveyed by Scott to determine their use of analogies. He prepared a listing and classification of all analogies, and developed guidelines to make clear the theoretical basis for teaching through analogy. Brewington studied the freshmen chemistry students at the University of Arkansas and found the University's Algebera Test to be a valid instrument for predicting academic success in beginning chemistry.

Although not generally considered a part of science education, two studies in home economics have been reported because of their implications

for health education. A historical review of the origins, development, and present status of home economics and nutrition teaching by means of a questionnaire on undergraduate nutrition courses and teacher preparation employed by 72 institutions was conducted by Jordan. The public's general health knowledge, including students, seems to be gradually improving on various health topics, according to Kilander's study, although this improvement was not considered equal for each of the major health areas or for certain individual topics. In addition to these studies, Kowalski developed criteria for a college science honors program for general education, and Emira developed a sourcebook on solar energy for science teachers.

Studies Related to Learning.--Hoover and Schutz administered a 92-item attitude inventory to 785 juniors and seniors of 14 different institutions, 392 of whom were forestry and science majors, and 393 non-science majors. The study suggested that ordinary "science education" had little impact on basic conservation attitude patterns. De Sena studied 1,061 freshmen male students enrolled in science curricula at the Pennsylvania State University and concluded that common non-intellectual factors in the areas of interests, personality, problem areas, values, personal background, and academic and social adjustment to college could be identified as characteristics of consistent over-, under-, and normal-achievers as individual groups and which significantly distinguished them from each other. Brown used a questionnaire to assess the motivational practices employed by 88 Chemistry Departments in universities throughout the United States. From the 75 returned, there appeared to be definite distinctions between general

education chemistry courses and the first chemistry course for chemistry majors. There seemed to be no universal attempt to motivate students in a general education chemistry course, and the teaching procedures varied considerably. Murray tested a model for the interpretation of concept formation using 1,075 college biology students. The model was composed of cognitive information store, information processing, and emotional "set" store, and was analyzed by various specific tests. The results of this study suggested that the development of research for "analytic approaches" to learning biological knowledge, rather than focusing on performances after learning has taken place, ought to be the key concern in teaching.

Studies Related to Methods.--Programed instruction as a teaching method received the greatest amount of study during this period with five different sets of programed science materials being developed. Brown developed a program for college physical science, Joseph one in college physics, Nurnberger in ionizing radiation, De Lap and Leonardson in chemistry, and Phibbs a laboratory program in general biology dealing with fungi. All of the studies showed the students using the programed materials did as well, and in some cases slightly better, than those not using the programs as evaluated by various achievement criteria.

Several studies were undertaken to compare the relative effectiveness of various teaching methods with the "traditional" method of descriptive lecturing. Finger, Dillion, and Corbin jointly analyzed achievement of students enrolled in introductory college physics courses at Brown University as to the type of secondary school physics (PSSC, Conventional, None) they had taken. The marks in physics which could be predicted for each

group from their SAT-V and SAT-M scores were compared with the actual marks received. An analysis of covariance failed to show reliable differences among the three groups, although it was noted that the observed differnces favored the PSSC group. Four other studies--Fredenburg's study of the everyday topic approach as opposed to the historical-logical-subject matter orientation in general physical science; Schefler's comparison of the "discovery" and "traditional" methods in the freshman biology laboratory; Stoppel's analysis of the depictive and quantitive versus the traditional approach to teaching college chemistry; Zitelli's study of a cooperative teaching method versus a single teacher approach in basic physical science for non-science majors; and Strope's comparison of factual teaching and conceptual teaching in introductory college astronomy--all showed no significant differences between the two methods upon analysis of student achievement.

Another set of reports dealing with methods involved the development of various teaching innovations. Joseph developed a program in physics employing computer work, Musulin found operator formalism in dimensional analysis and statistical analysis to be feasible in the first year chemistry course, and O'Neill developed biology laboratory experiments to demonstrate the effects of certain hormones and hormone inhibitors on the development of young chickens. Evans reviewed selected literature and designed a program in general education using science as a system of inquiry. Kaplan found it possible to teach students to be more empirical, although no definitive statistical difference was established by teaching empiricism directly to students in a one-year integrated biology course as compared

with other science courses not teaching empiricism directly. White's study showed no significant differences in the biology knowledge and final grades of 174 general biology students taking four hours of laboratory per week and 157 taking only two hours per week. However, there were significant differences in achievement levels as measured by the laboratory composites.

Studies Related to Facilities and Equipment.--There were no studies reported on facilities for college science teaching and only four on equipment innovations, and these primarily involved development, excluding systematic evaluation. Two of these dealt with the development of anatomical models for use in biology courses. Naiman designed and produced a dissectable model of the human brain and Silverstein analyzed the effectiveness of student construction of three-dimensional anatomical models of the fetal pig.

Two additional studies dealt with various kinds of apparatus. Morris had a panel of physical science teachers evaluate new demonstration apparatus for use in general education physical science courses. Ewing developed a series of pre-assembled instruments with uniform input and output connectors and a supply of patch cords so that the student could interconnect them in any desired manner to form different modules for use in analytical chemistry.

Studies Related to Teacher Education.--An interesting study involving teacher preparation was Bunnell's survey of differential participation in NSF institutes by high school teachers from the rural, urban, and suburban and city areas of Chicago. It was found that participants tended to be the better prepared teachers, there tended to be greater use

of institutes by urban and suburban teachers, the majority of the Chicago city teachers who attended instututes went to in-service programs; and those schools with the majority of their science and math teachers NSF institute alumni had twice as many classes using the new NSF sponsored curricula (SMSG, PSSC, CBA, CHEMS, BSCS) as those schools having less than half of their science and math teachers as institute alumni.

Six of the reported studies were designs or evaluations of curriculum programs in science for the preparation of elementary teachers. Hardin evaluated the adequacy of the University of Miami program from both the overall elementary school science area and from identified sub-areas of elementary school science and found prospective elementary teachers inadequately prepared in science, although there was a degree of preparation in each of the defined sub-areas. Howe and Buell suggested using the biological principles presented to elementary school students in the fourth, fifth, and sixth grades; and Thomas suggested using a uni-phylum approach to zoology via the Arthropoda as the basis for a pre-service biology course for elementary education majors. Kisner found the science content of prospective elementary school teachers in eight Oklahoma institutions to be compatible with the preparation recommended by authorities, but Moser found the majority of the elementary school teachers of a group of 1,945 New York teachers to have inadequate science backgrounds, with 22% having had no science training whatsoever beyond the high school level. Service analyzed the science education programs in the California elementary schools, investigated the recommendations and requirements in academic science for the prospective elementary school teacher, and then

made recommendations regarding the nature and substance of the science preparation of elementary teachers.

Several studies also dealt with the preparation of secondary science teachers. Anderson's general analysis of the preparation programs for secondary school science teachers made of 78 institutions revealed a great diversity with several phases of the program at a majority of the schools appearing inadequate in breadth and depth of science in experiences planned specifically for the science teacher and in experimentation, with the majority of the prospective science teachers taking less than 50% of their course work in science. Stapleton evaluated two programs of student teacher supervision of student teachers in science and found the program of intensified college supervision produced a higher level of performance as compared to the performance of a control group without such supervision as evaluated through ratings of supervising teachers and college supervisors each of whom used the Revised Indiana and Cornell Scales. Other studies included a survey of the events and trends in programs for the preparation of astronomers in the United States from 1947-60 by Claridge, a proposed curriculum for the preparation of earth science teachers by Shrum, and a curriculum designed for the pre-service preparation of secondary school physical science teachers in Jordan by Farhan.

Studies Related to Evaluation and Research Design.--Two studies, one by Naibert and the other by Woodward, analyzed various factors in students' records to determine the predictability of achievement in college chemistry in the former and college physics in the latter. Woodward found the college cumulative average and the college mathematics average to be the

best predictors, while Naibert found the average grades attained in all high school mathematics courses to be the best predictor. Both studies thereby agreed on the importance of adequate mathematics preparation for high achievement in college chemistry and physics. The other studies in this area were less related and included an evaluation of a general physical science course at the University of Oklahoma by Yoesting and Renner showed that the course made a significant contribution toward developing student ability to think critically. Also, Carr developed a new type of evaluation technique in which he graded sophomore physics laboratory work with the aid of a computer, finding it was more effective in determining significant figures in calculations, in finding arithmetical errors, and in determining the accuracy of the calculations, while requiring only one-eighth of the time of hand-grading. And Kapfer used a group of judges from the fields of science education, education, biology, chemistry, and physics to establish a list of 116 validated criteria for evaluating research and their application to science education.

INTERPRETATION

Although the efforts to locate all studies completed in college science education during this period were probably not completely effective, it is assumed that the majority of the research has been identified. Of the 59 studies thus recorded, it is of interest to note that 38, or almost two-thirds, of these were completed as doctoral theses or dissertations. Inasmuch as these, by their very nature, represent the investigators' first research efforts, it would be hoped that a greater amount of research might be conducted by those more experienced teachers or researchers already

in the field. A further trend worthy of noting is that there were approximately the same number of experimental, analytical, and synthetic studies, although over half of the t ly experimental reports were in the one area of teaching methods. Therefore, there would seem to be a need for a greater amount of experimental work covering more areas. The research was also limited almost exclusively to freshmen level college courses which would seem to leave a tremendous gap in critical analysis of our total college and university science programs.

Some encouraging points include the increased number of studies in the areas of learning, and facilities and equipment, for these were areas virtually unexplored in previous work. The numerous attempts to evaluate the "new" discovery, inductive, open-ended, or concept-centered method of science instruction seems to be a promising sign of a possible carry over from the recent NSF sponsored curriculum developments in the high school sciences and mathematics. However, it should be mentioned here that many of these studies suffered from faulty design, and therefore, their true value is very limited. Even though much of this research showed no differences in achievement between "traditional" and "new" methods, this does not necessarily mean that the experimental curricula are better or worse, but rather that in many cases the evaluative instruments are still inadequate. This is not always due to the lack of appropriate instruments--for new ones appear in several of the reported studies--but more often to their unavailability. It seems apparent throughout all educational research that there is now a definite need for a central clearinghouse to collect, evaluate, and categorize the various instruments as they are developed.

In teacher education, the great concern over the inadequate preparation of teachers in science particularly at the elementary level, and the several curriculum designs for filling this void are are also hopeful. Although there was only one reported attempt at analyzing the comparative achievement of college students in the various sciences as to their high school preparation, namely "traditional" versus "modern"--and this may be due to the relatively small number of students in college having had any of the "modern" high school curricula--it is encouraging. Hopefully more studies of this nature are being conducted at present, for inasmuch as these new curricula are considered better than adequate preparation for college, it would seem important to determine the validity of this assumption.

In general, then, it would appear that there is still an abundance of research to be done in college science education. Not only do numerous problems need solving, but much basic investigation is needed to clearly define new problem areas. The reported surveys of college physics teaching, geoscience programs, and the preparation of astronomy teachers, all are practically pioneering efforts. Although some of these programs clearly lack polish, they are at least a beginning.

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* The studies designed by this mark will appear as future abstracts in the Office of Education's publication, Research in the Teaching of Science, Studies Completed 1963-1964, College Section.